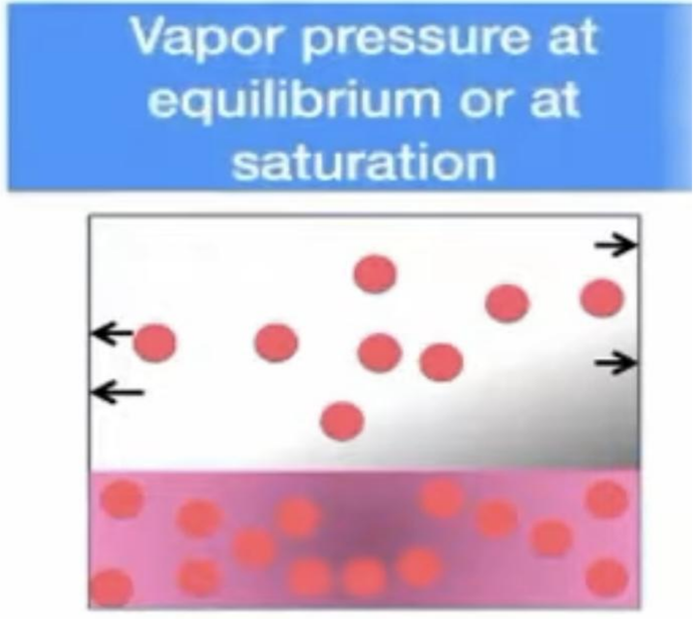
Vaporizer

A vaporizer in an anesthesia machine is a device that turns a liquid anesthetic into a vapor and adds a precise, adjustable amount of this vapor to the fresh gas flowing to the patient

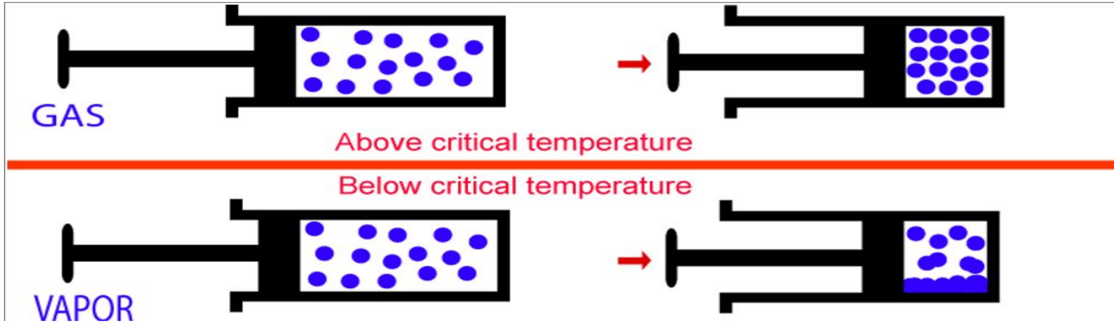
Saturated vapor pressure (SVP)

- The pressure exerted by a vapor on the walls of container when it is in equilibrium with its liquid phase at given temperature
- Amount of anaesthetic vapor depends on agents SVP
- Higher temp→more vapors→svp increases


Vapor pressure at equilibrium or at saturation

Critical temperature (CT)

- Temperature, above which a substance cannot be liquified, irrespective of pressure→Now it is **GAS**.
- Below CT the substance can exist as **liquid** or **vapour**.

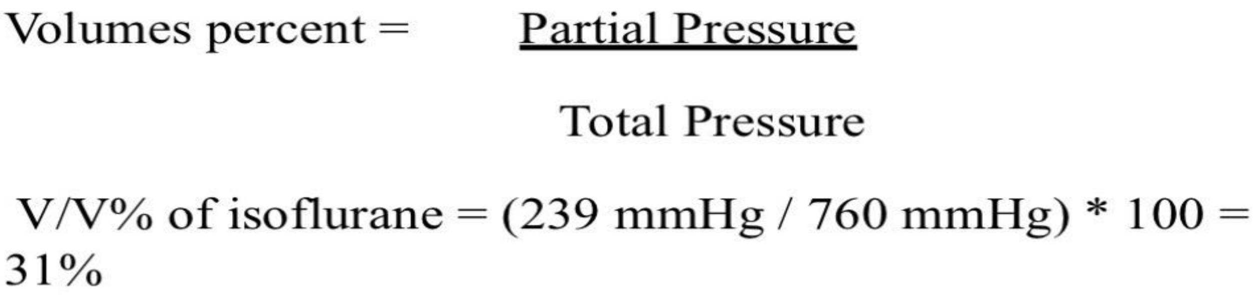

GAS
Above critical temperature
Below critical temperature
VAPOR

Boiling point

- It is the temperature at which the vapour pressure of a liquid equals the atmospheric pressure surrounding the liquid
- For Boiling, SVP=Atmospheric Pressure
- **High altitude →less Atmospheric Pressure→Low Boiling point→Easy Vapourisation**

Measurement of Vapour Quantity

- **Percentage of total volume (V/V%)**:-Volume of anaesthetic vapour per 100 volumes of the total gas mixture.



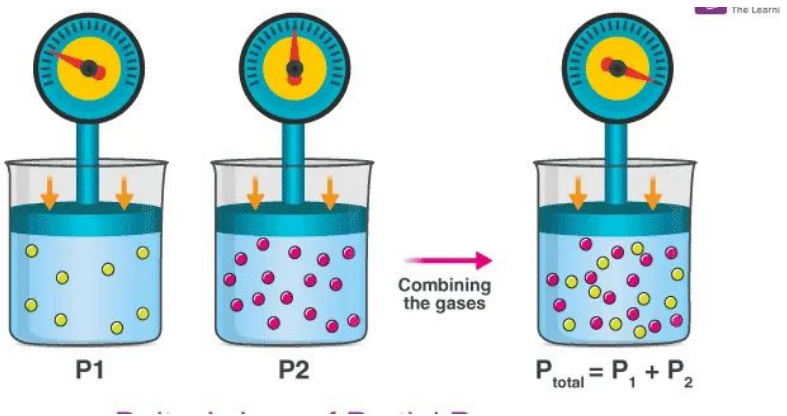
$$\text{Volumes percent} = \frac{\text{Partial Pressure}}{\text{Total Pressure}}$$

V/V% of isoflurane = (239 mmHg / 760 mmHg) * 100 = 31%

- Absolute pressure (mmHg / kPa) → **Dalton's law of partial pressure**

Dalton's Law of Partial Pressures

It states that the total pressure exerted by a mixture of gases is equal to the sum of the partial pressures of the individual gases in the mixture.


The Learni
P1
P2
Combining the gases
$P_{total} = P_1 + P_2$

Minimum alveolar concentration (MAC)

It is the **minimum** alveolar concentration **at sea level** of an inhaled anaesthetic required to prevent movement in **50% of patients** in response to a **standard surgical stimulus**.

- It is conventionally expressed as a percentage of alveolar concentration at one atmosphere pressure (760 mm Hg).

Physical properties of potent inhaled volatile agents

	Hal	Iso	Sevo	Des
Molecular wt	197.4	184.5	200	168
Boiling Pt	50.2	48.5	58.5	23.5
SVP at 20C	243	238	160	666
MAC	0.75	1.15	2	6
ml of vapor per ml of liquid at 20C	226	195	182	207

Heat of vaporization

- It is the number of calories needed to convert **1 ml of liquid to vapor.**
- It results in loss of heat and **temperature** of liquid **falls**.
- Thus it **reduces vapour pressure** and vaporizer output.

- **Specific heat** →is the number of calories needed to increase the temperature of **1 g of a substance by 1 degree Celsius.** **Vaporizer – materials with high specific heats to minimize temperature changes associated with vaporization.**

- **Thermal conductivity**→ a measure of how fast a substance transmits heat. **High thermal conductivity is desirable in vaporizer construction.**

Materials used in the construction of vaporizers

- Copper
- Aluminum – MRI compatible vaporisers
- Brass
- Steel
- Glass

Characteristics of Ideal VAPORIZER

- Performance not affected by changes in :
  - FGF
  - Volume of liquid agent
  - Ambient temperature & pressure
- Low resistance to flow
- Lightweight with small liquid requirement
- Economical and safe to use
- Corrosion and solvent-resistant

Classificationof Vaporizers

Method of regulating output

- Variable bypass- ether, TEC
- Measured flow-Cu kettle

Method of vaporization

- Flow over
  - With wick-TEC vaporizer
  - Without- Goldman bottle
- Bubble through- Cu kettle
- Injection- desflurane

Location

- In circuit- OMV, Goldman bottle
- Out of circuit- TEC vaporizer

Temperature compensation

- Thermo compensated
  - Altered flow-TEC vaporizer
  - Supplied heat- Cu kettle
  - Both above – OMV
- Non compensated- ether bottle

Agent Specificity

- Agent specific- TEC vaporizer
- Multi agent- Goldman bottle

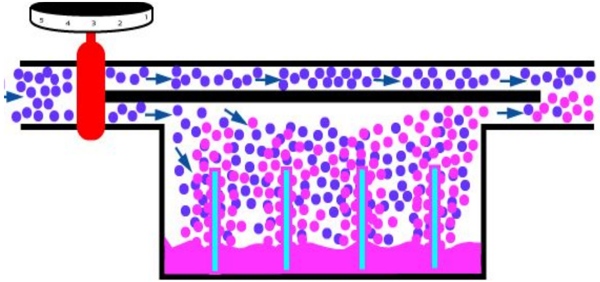
Resistance

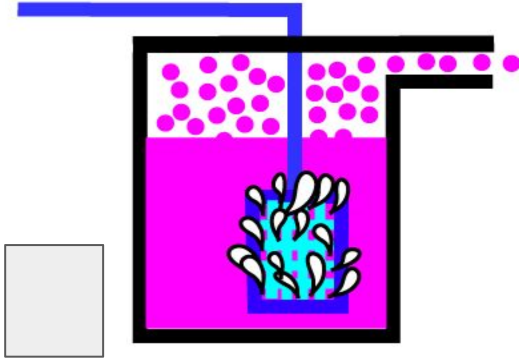
- Plenum (high)- TEC vaporizer
- Draw over (low)- Goldman bottle, OMV

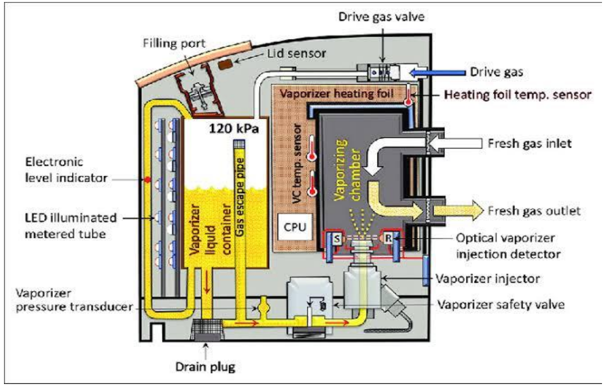
Method of Vaporization

The pathway followed by the carrier gas as it travels through the vaporizing chamber.

- **Flow over**
- **Bubble through**
- **Injection Vaporizer**



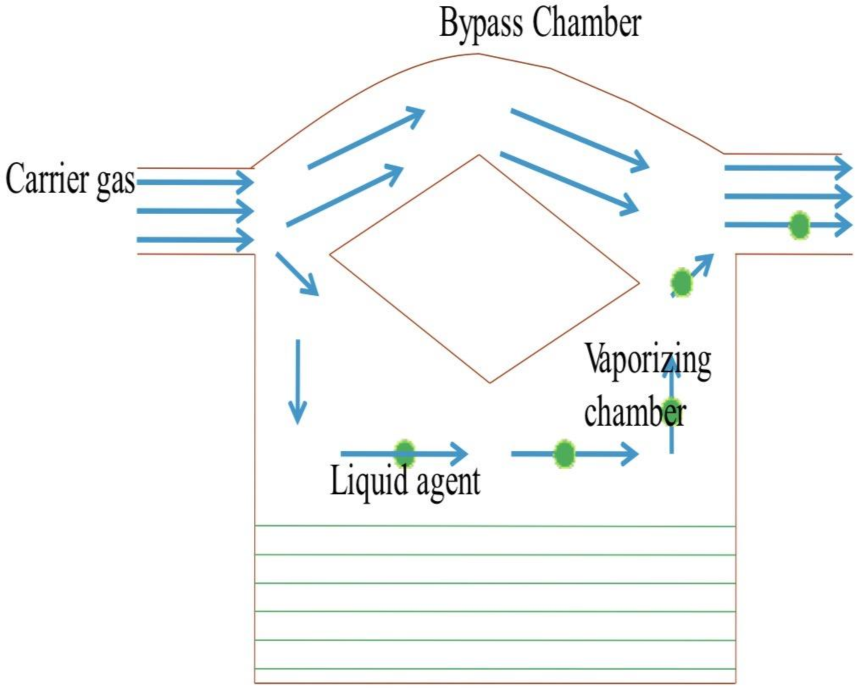



Drive gas valve
Filling port
Lid sensor
Drive gas
Vaporizer heating foil
Heating foil temp. sensor
120 kPa
Fresh gas inlet
Electronic level indicator
VC temp. sensor
Vaporizing chamber
Gas escape pipe
Vaporizer liquid container
CPU
Fresh gas outlet
LED illuminated metered tube
S
R
Optical vaporizer injection detector
Vaporizer injector
Vaporizer pressure transducer
Vaporizer safety valve
Drain plug

Variable Bypass

- Fresh gas flow (FGF) enters the inlet of the vaporizer and splits into
- Carrier gas
- Bypass gas

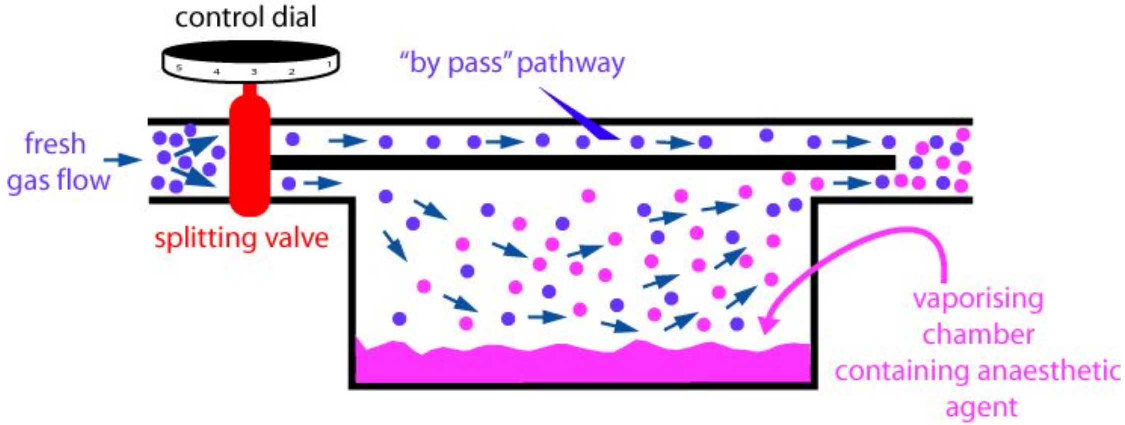
- At the outlet, the Bypass gas meets the Carrier gas (fully saturated with vapor)


Bypass Chamber
Carrier gas
Vaporizing chamber
Liquid agent

SPLITTING RATIO:

Ratio of gas flowing through bypass channel to that flowing through vaporizing chamber.

- **Depends on :-**
  →Ratio of Resistance in two pathways
  →total flow of vaporiser


control dial
5
4
3
2
1
"by pass" pathway
fresh gas flow
splitting valve
vaporising chamber containing anaesthetic agent

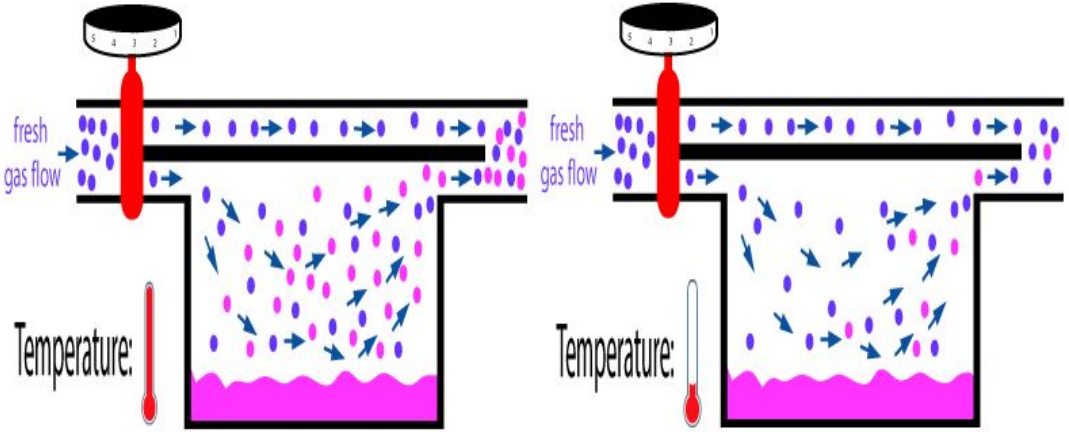
Temperature Compensation

- Molecules consumes Energy to escape and become vapor

Compensatory mechanism

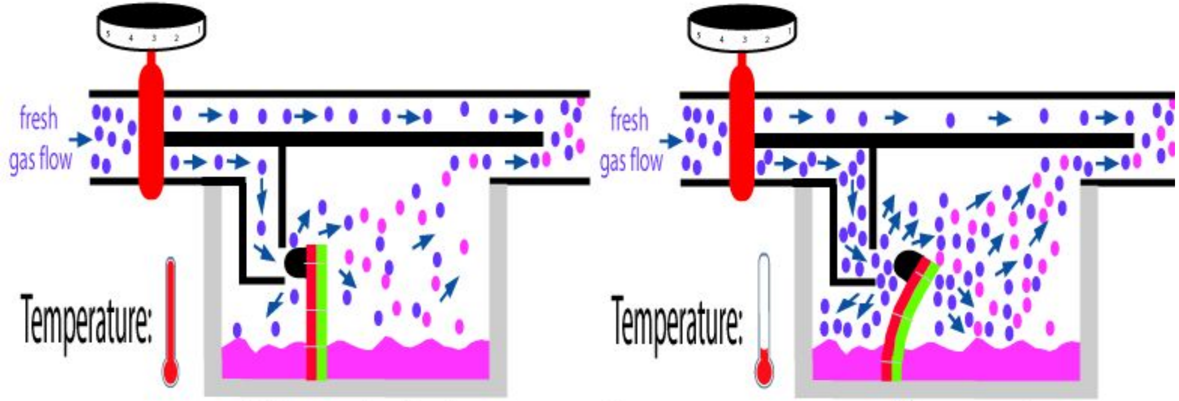
- Bimetallic strip
- Electrically heated tec 6
- Computer control-

  Electronic Vaporizer


5 4 3 2 1
fresh
gas flow
Temperature:
5 4 3 2 1
fresh
gas flow
Temperature:

Bimetallic strip

The bimetallic strip is fixed in such a way that it offers a **resistance** to flow entering the vaporising chamber. When the temperature drops→the bimetallic **bends and moves away**→decreases the resistance to the flow →**flow increases**


fresh
gas flow
Temperature:
fresh
gas flow
Temperature:

Bi-metalic temperature compensating valve

Factors Affecting Vaporizer Performance

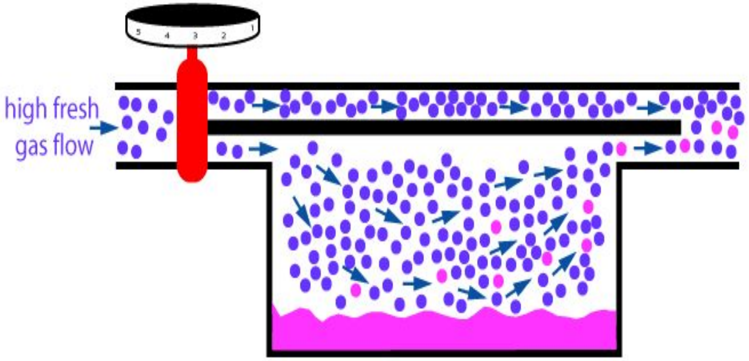
- Flow rate of fresh gas.
- Extremes of temperature.
- Pumping Effect/ Pressurizing Effect
- Barometric pressure
- Anaesthetic agent

Problem of High Flow

At **high flows**, the vaporizer delivers **less anesthetic concentration** than is set on the dial gas flow

At high flows, there is inadequate vaporisation.

- **Wicks improves vaporisation**



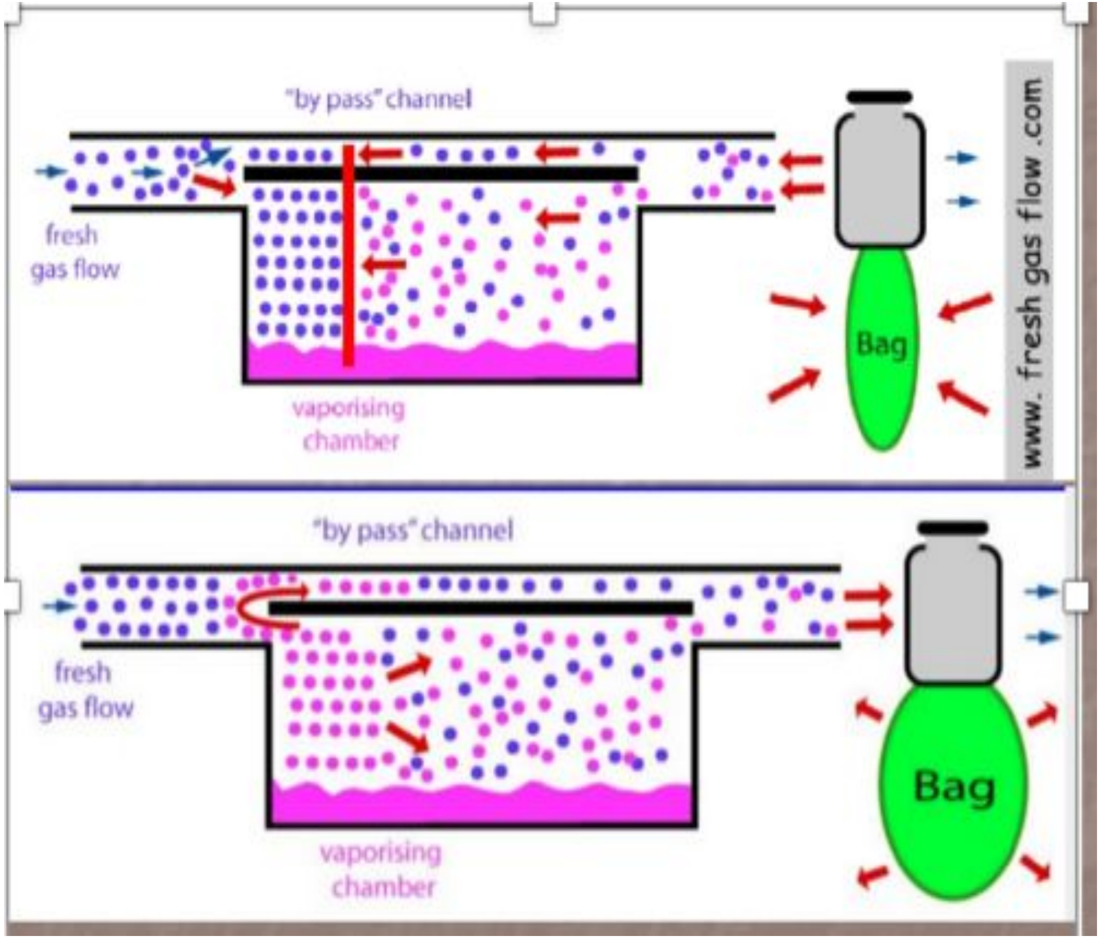
At high flows, there is inadequate vaporisation

Pumping Effect

(Hill and Low effect)

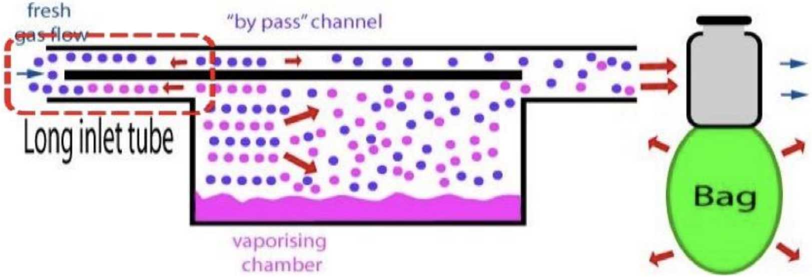
- ❖ IPPV
- ❖ Oxygen Flush

→They increase vaporizer output

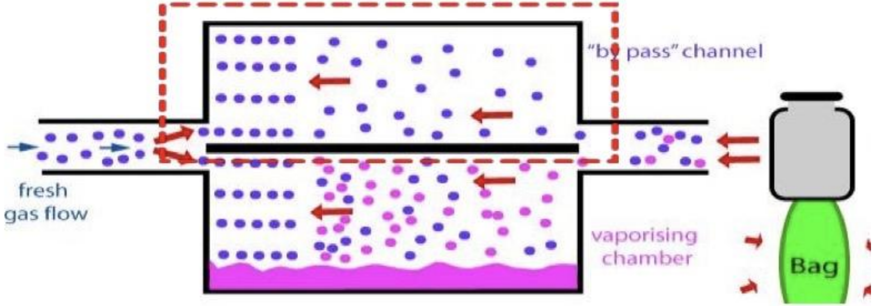

"by pass" channel
fresh gas flow
vaporising chamber
Bag
www. fresh gas flow .com
"by pass" channel
fresh gas flow
vaporising chamber
Bag

Modifications to reduce pumping effect

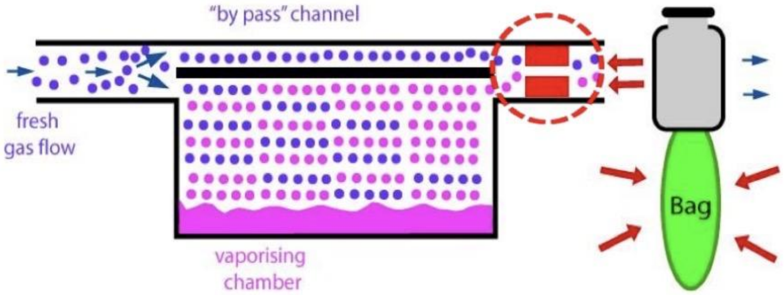
Long inlet tube


fresh gas flow
"by pass" channel
Long inlet tube
Bag
vaporising chamber

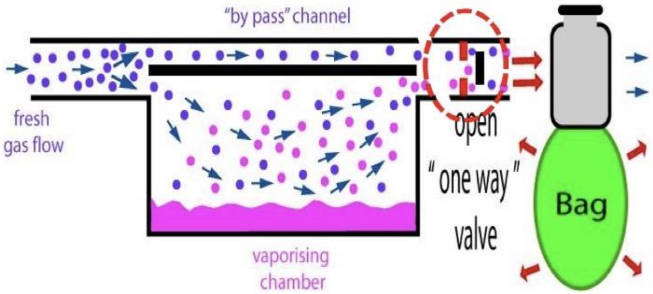
Large bypass channel


"by pass" channel
fresh gas flow
vaporising chamber
Bag

Increased resistance

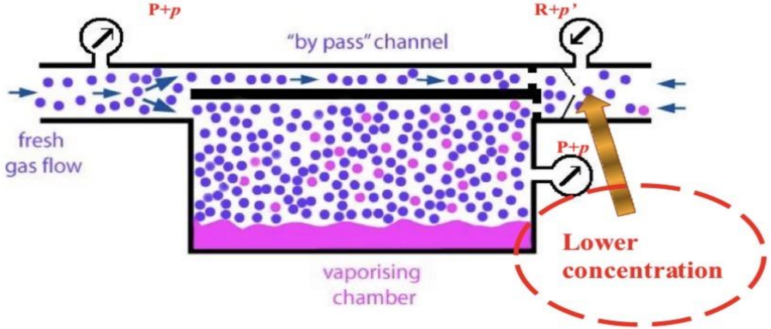

"by pass" channel
fresh gas flow
Bag
vaporising chamber

One way valve

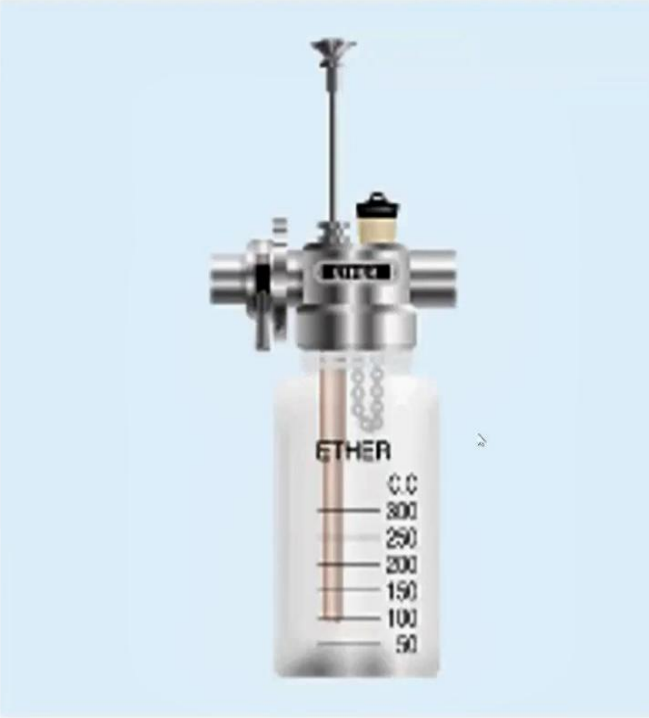

"by pass" channel
fresh gas flow
open
"one way" valve
Bag
vaporising chamber

Pressurizing effect

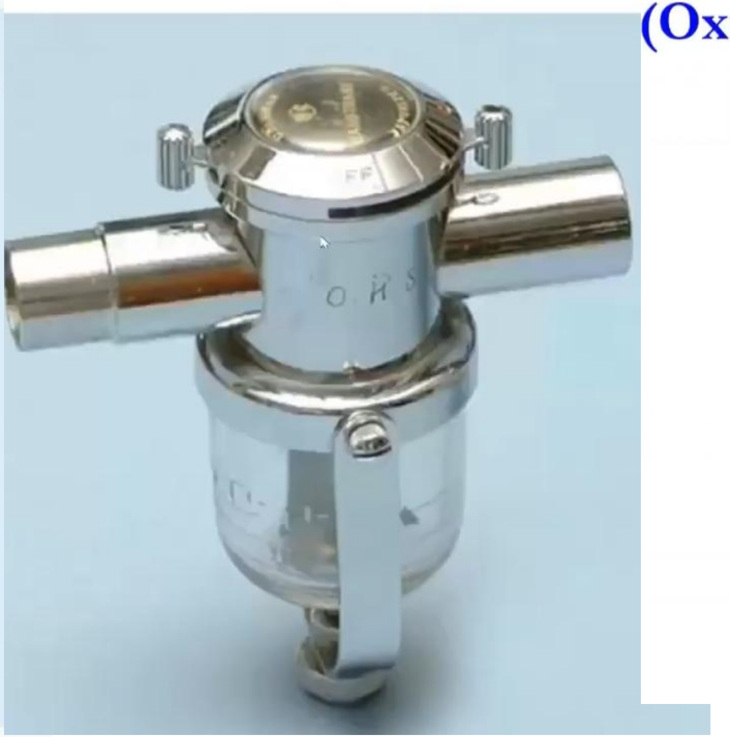
- **Cause:** High gas flow rates through the vaporizer.
- **Mechanism:** The fresh gas passing through the vaporization chamber is compressed by the high flow. Since the number of vapor molecules is dependent on temperature, not pressure
- **Effect on output:** Decreases the concentration of the anesthetic output.


P+p
R+p'
"by pass" channel
fresh gas flow
P+p
Lower concentration
vaporising chamber

Boyles Bottle

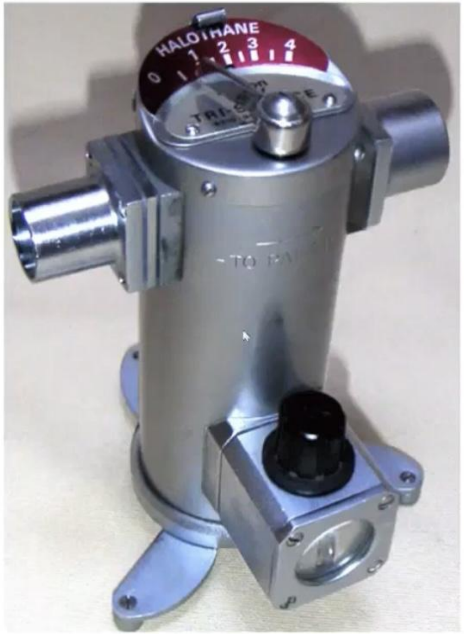

ETHER
C.C
300
250
200
150
100
50

Goldman Vaporizer



OMV

(Oxford Miniature Vapori


HALOTHANE
0
1
2
3
4

Features of modern vaporizer

- Variable bypass- Fresh gas splits into bypass gas and carrier gas
- Flow over- Carrier gas flows over the surface of the liquid volatile agent in the vaporizing chamber
- Temperature compensated- Equipped with automatic devices that ensure steady vaporizer output over a wide range of ambient temperatures
- Agent-specific
- Only calibrated for a single gas, usually with keyed fillers
- Out of circuit

TEC Vaporizers

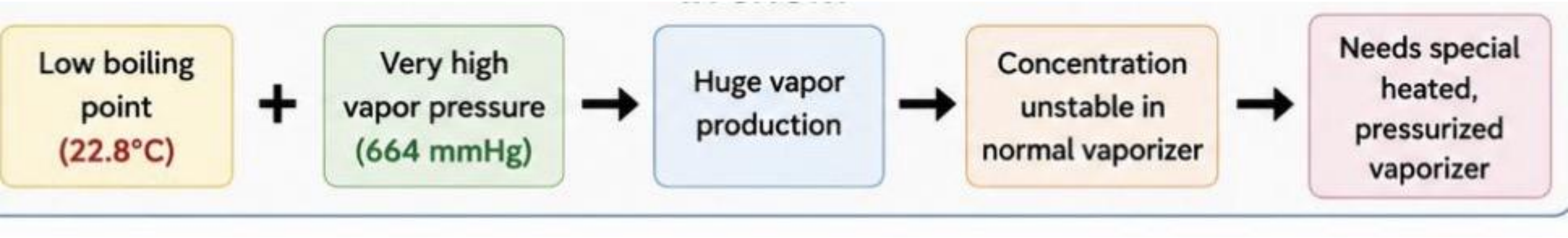
Tec 2 Vaporizer

Use Only Halothane

Classification (TEC I-V)

- Variable bypass
- Flow over with wick
- Out of system
- Temperature compensated by automatic flow alteration
- Concentration calibrated
- Agent specific

Why Desflurane has separate Vaporizer??



Low boiling point (22.8°C)

+

Very high vapor pressure (664 mmHg)

→

Huge vapor production

→

Concentration unstable in normal vaporizer

→

Needs special heated, pressurized vaporizer

Datex-Ohmeda Tec 6 Vaporizers for Desflurane (1989)

Specifically designed to deliver Desflurane

Described as a **gas/vapor blender** than as a vaporizer.

It is heated electrically to 39^0 C

Pressurized Device with a pressure of 1550 mmHg (2 atm)

Electronic monitors of vaporizer function

FGF does not enter vaporization chamber, instead **Desflurane vapor enters the path of FGF**

Percentage control dial regulates flow of Desflurane into FGF

Dial calibration is from 1% to 18%

Provided with back up 9 volt battery

TEC - 7

- The latest model of the TEC series
- It delivers Isoflurane, Sevoflurane, Enflurane and Halothane efficiently
- Accommodates 225 mL of anesthetic agent.
- Non-spill system limits movement of liquid agent
  - if the vaporizer is tilted or inverted
  - helping to protect internal components.

Concentration calibrated, plenum type, Variable bypass, Flow over with wicks, Temperature compensated, out of circuit, agent specific

Advantages

- Easy to use and reliable.
- Properly calibrated
- This type of vaporizer does not require a power source.

Disadvantages

- High internal resistance
- The heat sink makes the vaporizer heavy -
- There are no alarms
- Temperature compensation only works within a reasonable range of ambient temperatures.

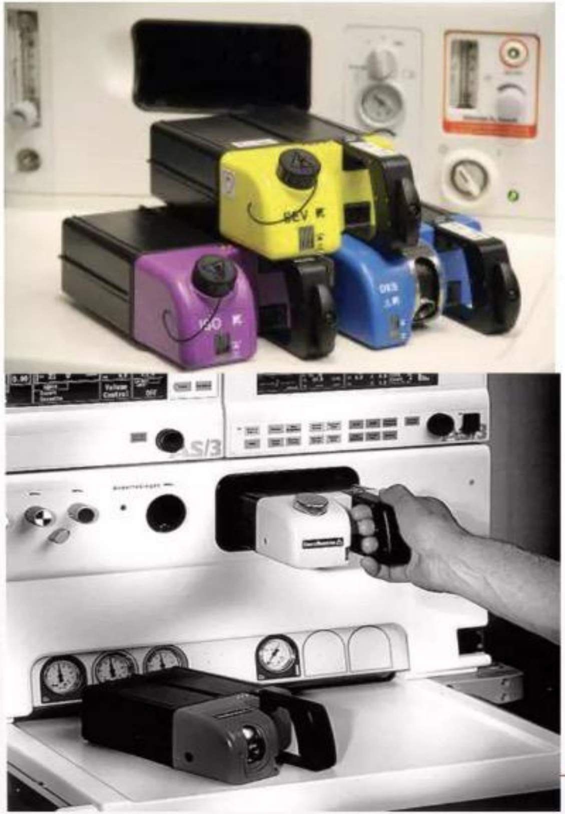
DRAGER VAPORIZER

- Classification
- Conc calibrated
- Flow over with wick
- Out of system
- Thermal compensation
- Agent specific

"T" Transport Position: Allows safe shifting, tilting, or upside-down transport without agent leakage or internal flooding.

0.6 0.4 0.2
ON
0
T
S
Vol.%
Dräger
Sevoflurane
Vapor 2000
Dräger Fill

Aladin Cassette Vaporizer System



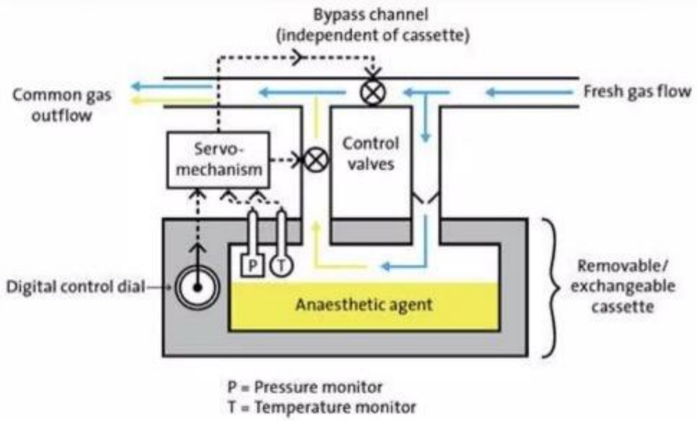
- A Novel system
- Single vaporizer capable of delivering 5 different anaesthetic agents
- It is designed for use with Datex-Ohmeda S/5 ADU and similar machines.
- FGF is divided into bypass flow and liquid chamber flow
- Liquid chamber flow conducted into agent specific, color coded cassette in which volatile anesthetic is vaporized
- Machine accepts only one cassette at a time
- Magnetic Labeling

Advantages

- Automated recognition of the agent inserted.
- On-screen data showing agent levels and anaesthetic usage.
- Automated, electronically monitored and controlled FGF, temperature and pressure compensation.
- No risk of spillage of anaesthetic agent into the bypass channel.
- Cassette can be carried safely in any orientation.

Disadvantages

- Specific to a particular branded anaesthetic machine.
- Anaesthetic delivery requires electrical power.


Bypass channel
(independent of cassette)
Common gas outflow
Fresh gas flow
Servo-mechanism
Control valves
P
T
Digital control dial
Anaesthetic agent
Removable/ exchangeable cassette
P = Pressure monitor
T = Temperature monitor

Hazards with vaporizers

1.Incorrect Agent

2. Tipping

3. Overfilling

4. Reversed Flow

5. Control Dial in Wrong Position

6.Leaks

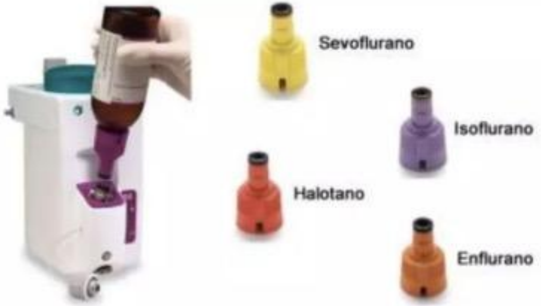
7. Vapour Leak into the Fresh Gas Line

8. Contaminants in the Vaporizing Chamber

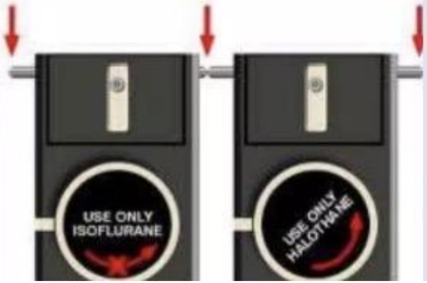
9. Physical Damage

10. No Vapor Output

Safety features

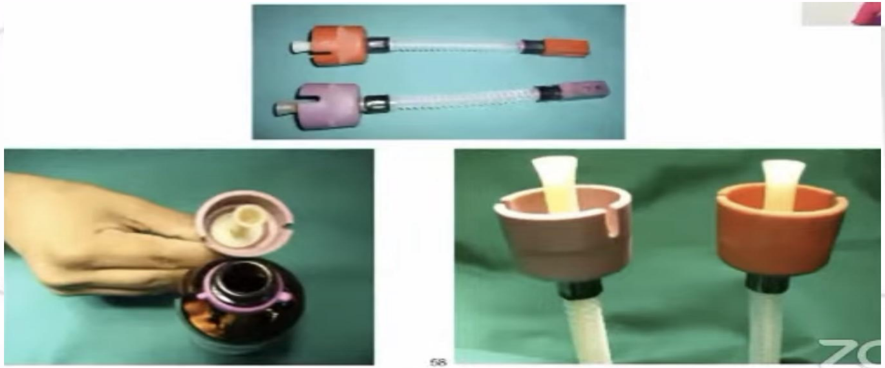

Sevoflurano
Isoflurano
Halotano
Enflurano

- Color specific (for each agent)
- **Keyed fillers bottles**
- Low filling port
- Vaporizers are locked into the gas circuit, thus ensuring they are seated correctly.
- **Secured vaporizers Interlocks**
- less ability to move them about minimizes tipping
- **Only one vaporizer is turned on**
- **Trace vapor output is minimized when the vaporizer is off**
- Concentration dial increases output in all when **rotated counterclockwise**.


USE ONLY ISOFLURANE
USE ONLY HALOTHANE

Filling system

- Bottle Keyed System
- Funnel Fill System
- Keyed Filling System
- Quick-Fill System
- Easy-Fill System
- Desflurane Filling Systems



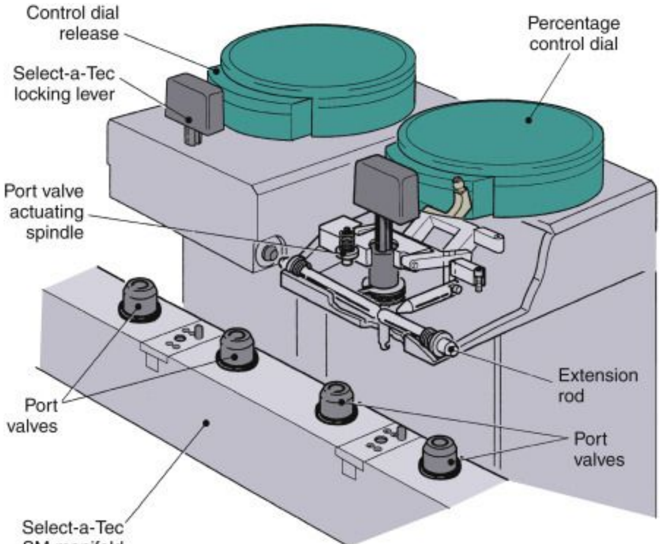
Key-fil

Tec 7
SEV
fresh gas flow .com

Quick fill system

Protection offered by select-tec and interlock

- The vaporizer can be turned on only when it is attached to the back bar and locked
- Only when the vaporizer is turned on, fresh gas can flow through it
- Only one vaporizer can be turned on at a time


Control dial release
Select-a-Tec locking lever
Percentage control dial
Port valve actuating spindle
Extension rod
Port valves
Port valves
Select-a-Tec